

[54] **APPARATUS FOR VOLUMERIC FEEDING OF FIBROUS MATERIAL**

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[51] Int. Cl. **D01g 23/06**

[58] Field of Search **222/55, 56, 414, 1, 144.5; 19/80 R, 105, 240**

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[57] **ABSTRACT**

A method for the controlled volumetric feeding of fibrous materials such as fiber glass and asbestos which comprises the steps of forming a feed reservoir of the fibrous material; compressing the fibrous material in the reservoir; moving pronged conveying means through the compressed material at the reservoir discharge, thereby entraining the fibrous material on the pronged conveying means; confining the entrained fibrous material on the pronged conveying means; and removing the entrained material.

Apparatus for use in the method includes at least one hopper for the fibrous material, having an open bottom; means for applying a compressive force to the fibrous material in the hopper; conveying means for receiving the fibrous material from the hopper having a plurality of prongs for entraining the fibrous material; means for driving the conveying means past the open hopper bottom whereby said fibrous material is forced by said compressive force onto the prongs; confining means for holding the entrained material on the prongs after advancing past the open hopper bottom; and means for removing the entrained fibrous material from the prongs.

9 Claims, 11 Drawing Figures

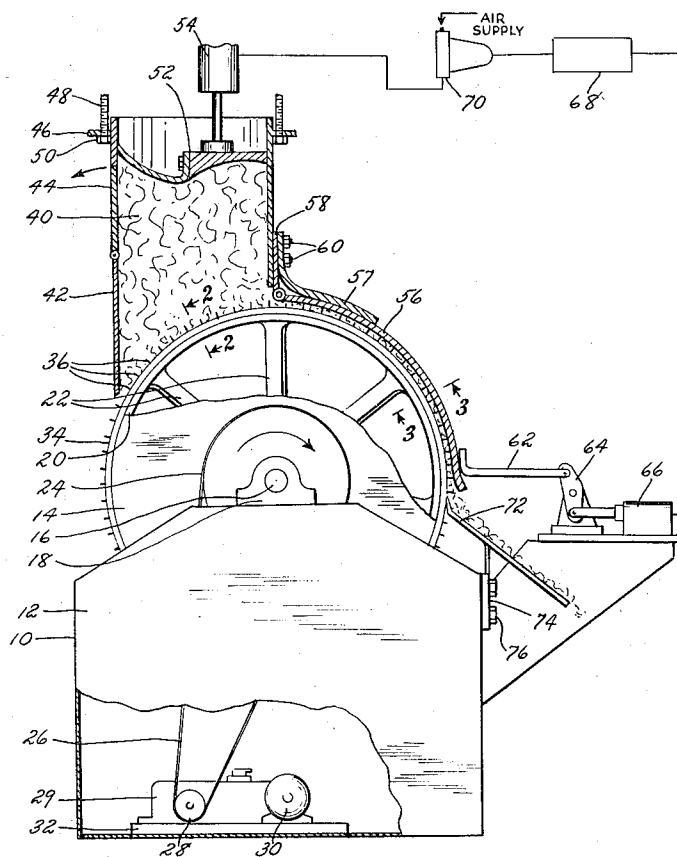


Fig. 1

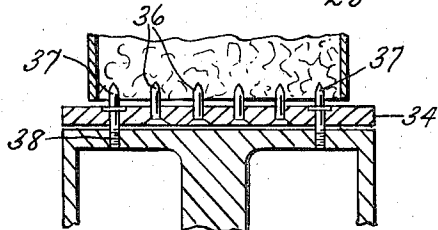
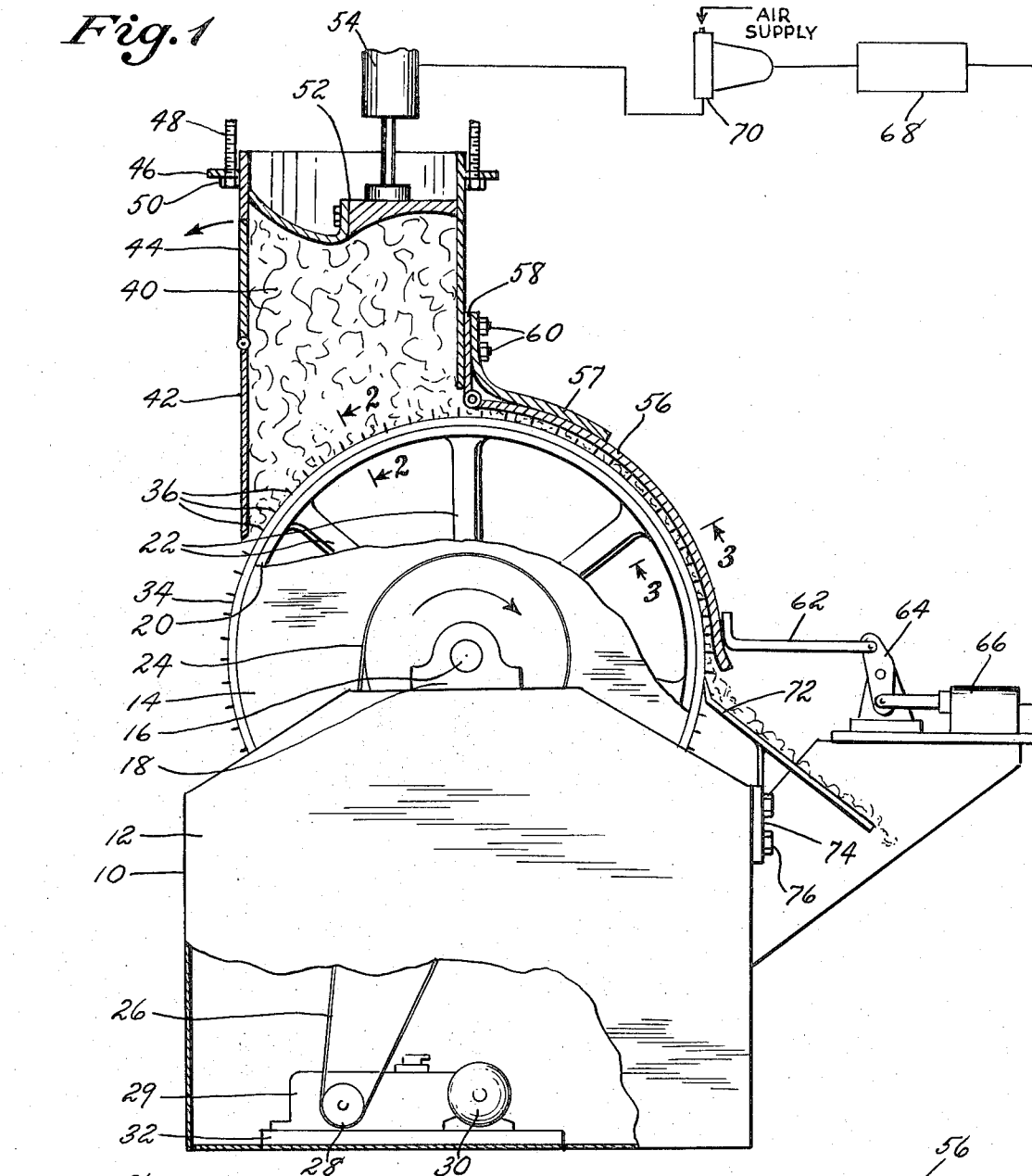


Fig. 2

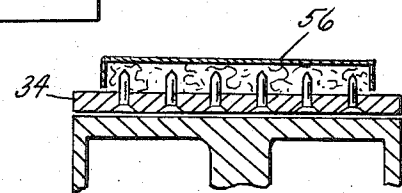


Fig. 3

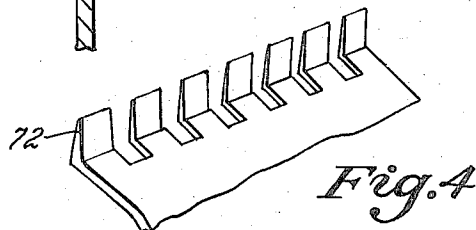


Fig. 4

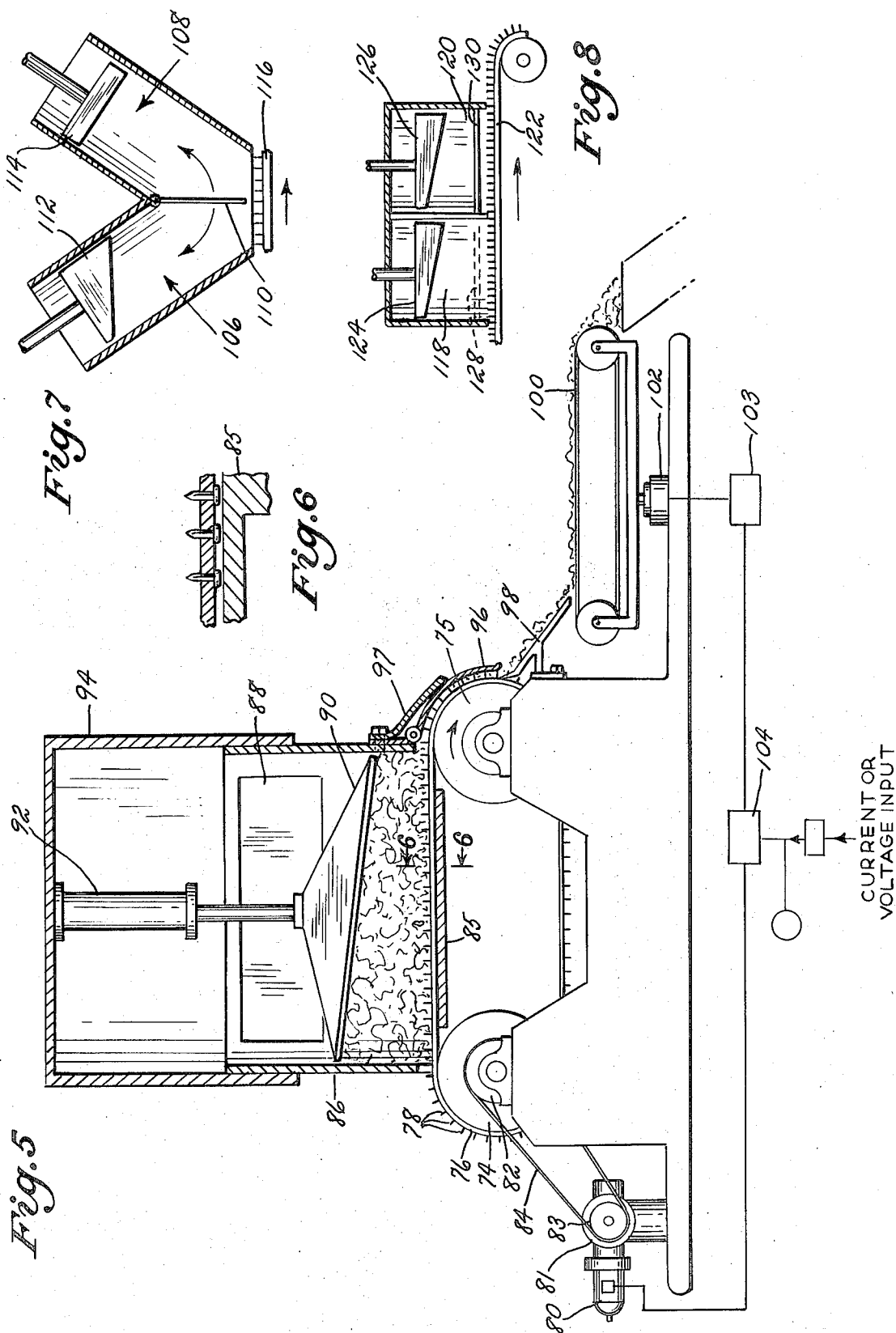


Fig. 10

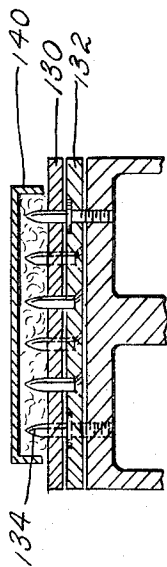


Fig. 11

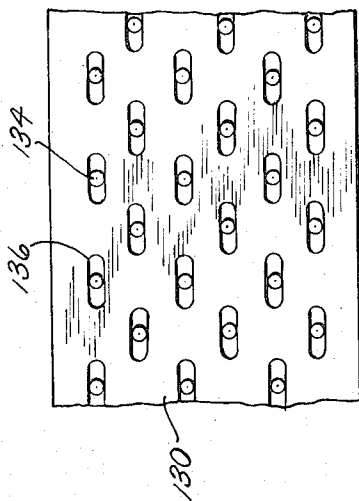
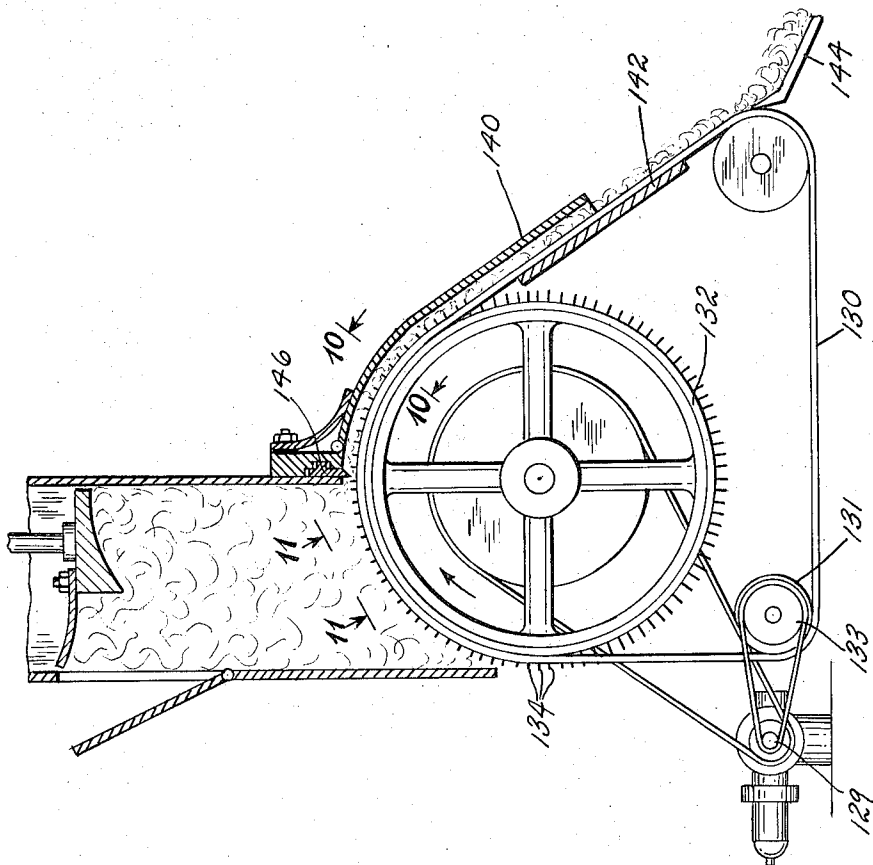


Fig. 9



APPARATUS FOR VOLUMERIC FEEDING OF FIBROUS MATERIAL

BACKGROUND OF THE INVENTION

This invention relates to a volumetric feeding method and apparatus for metering the controlled volumetric rate of flow of fibrous materials, such as chopped fiber glass, asbestos, sisal, cellulosic fibers and organic polymeric materials. More particularly, the invention relates to a method and apparatus wherein the fibrous material is subjected to a compressive force to facilitate the withdrawal of the material from the bottom of a storage hopper by an advancing pronged conveying means on which the material is entrained prior to removal therefrom. Such apparatus also may be utilized as a prefeeder to any type of gravimetric feeder.

A wide variety of fibrous materials have been employed in plastic products to improve the physical characteristics of the resultant extruded or molded products. For example, predetermined amounts of chopped fiber glass of a specific bundle size and length, with and without binders, have been used to reinforce thermosetting and thermoplastic resins in the manufacture of automotive molded parts, home appliance parts, and electrical molded parts in order to improve their tensile strength and Izod impact characteristics. Similarly, asbestos and chopped fiber glass have been used to modify phenolic, polyester, epoxy, melamine and silicone type polymerizable resins to provide plastic products having improved resistance to acids, alkalis, and temperature extremes. Also, chopped fiber glass must be accurately metered in the manufacture of fire-proof gypsum wallboard.

Automation of the manufacturing processes employing such fibrous materials has been hampered by the lack of an effective method and apparatus for feeding controlled volumes of such materials. Prior art methods used for volumetrically feeding fibrous materials employed vibrating feeders, rotary vane-type feeders, and augers or screw type feeders. However, these prior art feeding devices had a number of disadvantages. For example, chopped fiber glass and chopped organic polymers such as nylon tend to agglomerate or "ball up" due to the electrostatic build-up which occurs when mechanical energy is imparted to the material in storage and metering. Such agglomerates are not reduced in size by vibrating feeders, and the mechanical action within screw-type feeders tends to create agglomerates. Thus, the spasmodic discharge of such agglomerates from the feeders makes any high degree of volumetric accuracy almost impossible to achieve. In addition, the non-free flowing characteristics of the fibrous materials resulting from their size, shape, and bulk density make the metering of minute quantities difficult, if not impossible, to achieve with the known feeding devices.

SUMMARY OF THE INVENTION

In accordance with the present invention, a method and apparatus for the controlled volumetric feeding of fibrous materials are provided which overcome the disadvantages discussed above. In the described method and apparatus, the fibrous material within the storage reservoir is preloaded or compressed and a rotary or advancing pronged or spiked receiving and conveying means is provided to withdraw layers of the force-fed material from the bottom or discharge of the storage

reservoir. The fibrous material withdrawn from the lower section of the storage bin is entrained on the pronged conveying means and confined thereon by an entrapment segment which terminates adjacent to a predetermined discharge point on the conveying means. The confined material is removed at the discharge point using means such as scraper which must be suitably designed to provide clearance for the passage of the rows of prongs or spikes protruding from the surface of the conveying means, e.g., the periphery of a drum or a belt.

The described method includes the steps of forming at least one feed reservoir of the fibrous material; compressing the fibrous material in the reservoir; moving pronged conveying means through the compressed material at the reservoir discharge, thereby entraining the fibrous material on the pronged conveying means; confining the entrained fibrous material on the pronged conveying means; and removing the entrained material. The term "compressing" as used in the specification refers to the application of any force to the fibrous material which is effective to increase the bulk density of the fibrous material.

The apparatus suitable for use in the described method includes at least one hopper for the fibrous material having an open bottom; means for applying a compressive force to the fibrous material in the hopper; conveying means for receiving the fibrous material from the hopper having a plurality of prongs for entraining the fibrous material; means for driving the conveying means past the open hopper bottom whereby said fibrous material is forced by said compressive force onto the prongs; confining means for holding the entrained material on the prongs after advancing past the open hopper bottom; and means for removing the entrained fibrous material from the prongs.

The uniformity of the volumetric metering of the material in this method and apparatus is based on a constant cross-section and a constant density of material being withdrawn from the storage compartment and advanced by the pronged feeding conveyor. The constant cross section of material is controlled largely by the size, shape, and location of the prongs and the degree of compression maintained by the compression means and the confining means. The constant density is governed largely by both the speed of the pronged conveying means and the pressure to which the material is subjected. Finally, the required rate of material flow is controlled primarily by the speed at which the pronged conveying means pass through the pressurized material. Therefore, a number of variables must be integrated in order to achieve the desired controlled volumetric rate of flow.

This method and apparatus are suitable for use with a variety of fibrous material of varying cross sections and lengths. Fibrous materials which may be employed include fiber glass, pigment-impregnated fiber glass, asbestos, sisal, cellulose fibers such as cotton, and synthetic textile fibers such as polyamides, e.g., "Nylon," polyesters, e.g., "Dacron," polyacrylonitriles, e.g., "Orlon," and rayon. The foregoing fibrous materials exhibit varying bulk densities as well as varying physical and electrical properties.

In the described method and apparatus, agglomeration of the fibers is minimized because turbulence within the material in both the storage reservoir and the metering area of the conveying means is minimal. By

keeping turbulence to a minimum, segregation of powdered resin such as phenolic powder from plasticcoated fiber glass is also minimized, thereby obviating a quality control problem. Further, this method and apparatus is of a rugged construction and is relatively economical to manufacture.

BREIF DESCRIPTION OF THE DRAWINGS

Specific embodiments of the invention have been chosen for purposes of illustration and description, and are shown in the accompanying drawings wherein:

FIG. 1 is a side elevation, partially in section, of a drum feeder apparatus constructed in accordance with the invention;

FIG. 2 is a vertical section taken on line 2—2 of FIG. 1;

FIG. 3 is a vertical section taken on line 3—3 of FIG. 1;

FIG. 4 is an isometric drawing of the scraper of FIG. 1;

FIG. 5 is a side elevation, partially in section, of an alternate embodiment constructed in accordance with the invention including a belt-type feeder apparatus in combination with a weigh belt of a gravimetric feeder;

FIG. 6 is a partial vertical section taken on line 6—6 of FIG. 5;

FIGS. 7 and 8 are vertical sectional views of dual or twin hopper arrangements;

FIG. 9 is a side elevation partially in section of another embodiment including a drum-type feeder apparatus having a perforated conveyor belt which overlies the pronged belt;

FIG. 10 is a vertical section taken on line 10—10 of FIG. 9; and

FIG. 11 is a top view of the perforated conveyor belt of FIG. 9.

Referring to FIG. 1, the drum-type volumetric feeder apparatus of this invention is supported on a base 10 which is constructed of frame members which are not shown enclosed by panels 12 on opposite sides. A drum 14 is mounted on a rotating shaft 16 in the top opening of base 10. The shaft 16 extends through bearings 18 carried on opposite sides of base 10. The drum 14 is fixed to the shaft 16 by suitable means and comprises an outer surface 20 supported on a hub which is not shown by support members 22.

The shaft 16 is provided with a sprocket gear 24 connected by the chain 26 to the driving sprocket 28 on the end of the shaft of mechanical variable speed reduction drive unit 29 which is supported on base 32. The motor 30 is constant speed and drives a mechanical, variable speed unit 29 to rotate the shaft 16 on which drum 14 is fixed at varying speeds. The reduction drive unit may be a mechanical variable speed unit with a 10:1 range, an infinitely variable mechanical drive, or a selenium controlled rectifier direct current (SCR/DC) drive with a 30:1 range. Generally, the drum speed will vary from less than 1 R.P.M. to 10 R.P.M. or more, depending upon the drum diameter and width.

Fixedly attached to the surface 20 of the drum is a flexible belt 34 having prongs 36. The flexible belt 34 is preferably of metal or a flexible material, preferably possessing no electrostatic characteristics, and as shown in FIG. 2 is attached to the drum 20 by a few threaded prongs 37 secured in threaded openings 38. Use of threaded prongs or other threaded attaching

means to secure the belt to the drum facilitates employment of interchangeable pronged belts with varying prong designs and arrangements. The prongs 36 have projecting points, flat heads, and are shaped like spikes.

The fibrous material 40 is stored in hopper 42 having a hinged loading door 44 in the side thereof. Hopper 42 has an open top and an open bottom. A flange 46 is secured to the upper portion of hopper 42 and bolts 48 and nuts 50 adjustably secure the hopper 42 to a frame not shown.

In operation, a ram 52 operatively connected to an air cylinder 54 closes the top of hopper 42 and applies pressure to the fibrous material 40 therein. The pressure applied and the shape of the ram are variable and must be integrated with the material being compressed, the height of the material, the speed of the drum, and the shape and design of the prongs. Generally, the pressure will normally be reduced as the hopper empties, with less pressure being applied to the material adjacent the left side wall and a greater pressure applied to the material adjacent the right side wall to facilitate removal of a uniform horizontal cross-section of material. To retain the fibrous material on the flexible belt, the sides of the hopper are extended and are positioned to cooperate with the outer row of prongs on the flexible belt 34. As the drum 14 rotates in the direction indicated by the arrow, the prongs 36 entrain a progressively increasing amount of the fibrous material as they pass through the open bottom of the hopper 42 of feed reservoir.

After the prongs 36 having the fibrous material 40 entrained thereon advance past the open bottom of hopper 42, the material is confined thereon by a spring-loaded, adjustable, arcuate entrapment segment 56 which is hinged at its upper end and movable at its lower end. As indicated, spring 57 presses against the segment in order to maintain it in a compressive position against the material on the pronged belt. The distance of the entrapment segment 56 from the surface of belt 34 will usually be slightly greater than the height of prongs 36. The distance of the segment above the flexible belt is adjustable as the hinge of segment 56 is affixed to a slotted block 58 which can be moved up or down after loosening threaded members 60. As shown in FIG. 3, the sides of the entrapment segment are mounted closely to the belt surface to maintain the fibrous material on flexible belt 34.

As the purpose of arcuate entrapment segment 56 is to maintain a constant cross section of fibrous material of a substantially constant bulk density, the radial position of the entrapment segment 56 is readily adaptable to actuate an external automatic control. FIG. 1 illustrates such an automatic control system wherein sensing element 62 is operatively connected to entrapment segment 56 at one end and, at the other end, to linkage 64 which is connected to the input arm of a linear variable differential transformer (LVDT) type load cell 66. Signals proportional to the product thickness in the entrapment section are supplied from the load cell to controller 68 which controls regulating valve 70 in the air supply line to cylinder 54. Thus, when the thickness of the material in the confining section is too great, the amount of compression in hopper 42 is reduced by reducing the air pressure; and, conversely, when too little material is in the confining section, the amount of compression in hopper 42 is increased by increasing the air pressure.

Removing means such as scraper 72 is located adjacent to the point of discharge of entrapment segment 56. Scraper 72 is mounted on adjustable block 74 which is attached to base 10 by threaded members 76. As shown in FIG. 4, the scraper 72 is slotted, with the location and design of the slots coinciding with the location and design of prongs 36. In this manner the discharge of controlled volumes of fibrous material is achieved. Compressed air jets could be substituted for scraper 72 or used in conjunction therewith to remove the material.

In FIG. 5 an alternate embodiment of the controlled volume feeder apparatus is shown. In this apparatus the rotating drum is replaced by pulleys 75 which support an endless flexible belt 76 having prongs 78. The belt 76 is driven by motor 80 through sprocket 83 of reduction drive unit 81 and other apparatus 82 and 84 corresponding to that earlier described in connection with FIG. 1. A fixed slide plate 85 prevents deflection of the advancing pronged belt 76 in the area of the hopper discharge. Prongs 78 are further illustrated in FIG. 6 which shows they are in the shape of spikes with rivet-type heads.

In operation fibrous material is stored in feed reservoir 86, having been fed thereto through door 88 at the rear of the reservoir 86. A ram 90 operatively connected to hydraulic cylinder 92 mounted on frame 94 compresses the fibrous material against the pronged belt 76. As the belt moves past the open bottom of reservoir 86, the fibrous material is entrained thereon, confined by an adjustable, arcuate, entrapment segment 96 maintained in position by spring 97, and removed by adjustable scraper 98.

The substantially unvarying volumetric quantity of fibrous material discharges to a conventional weigh belt 100 having an accuracy of $\pm 0.25 - 1$ percent by weight which is continuously sensed by load cell 102. A proportional to weight signal is emitted by load cell 102 to controller 103 and continuously compared with the set rate or process input signal in a selenium rectifier controller (SCR) 104 which changes the armature voltage of the direct current motor 80, thereby increasing or reducing through gear reduction unit 81 the speed of flexible belt 76 having prongs 78. Such a system is suitable for processes requiring addition of precise quantities of fibrous material by weight.

In both the drum-type and rotary belt feeding apparatus, the head of fibrous material and the design of the ram for optimum operation will have to be experimentally determined by known methods because the nature and compressibility of the fibrous material, the speed of the belt, the hopper dimensions, the design of the prongs, and the shape, size, and pressure exerted on the ram each have an effect. Accordingly, all of these factors must be integrated with one and other in optimizing the feeding operation.

Since the fibrous materials which may be metered using the process and apparatus have varying bulk handling and physical characteristics, various arrangements of prongs and various prong lengths and designs may be employed. To provide this interchangeability of prong configurations, the prongs may be secured to separate endless lengths of interchangeable flexible belts which in turn can be secured to the drum or rollers as shown in FIG. 2 or by an alternate means for securing. Another alternative would be to insert all prongs into tapped openings in the surface of the drum.

Similarly, the shape of the ram, the dimensions of the feed reservoir, and the design of the confining segment and scraper are variable. For example, the sides of the drum may be extended to form a trough, the edges of which cooperate with the extended sides of the hopper. Such change obviously would also eliminate the need for sides on the entrapment segment.

To provide a continuous and uninterrupted flow of fibrous material, two pronged feeding devices may be positioned side by side for operation on a common drive shaft with a common discharge. For example, a solenoid operated clutch mechanism keyed to the drive shaft will either drive one feeder or the other. While one feeder is operating, the ram for the other feeder will be in a raised position to facilitate reloading the hopper above the feeder. The ram will then be lowered and when the level of material in the hopper of the operating feeder reaches a predetermined level, the solenoid will be energized thereby disengaging the clutch from the operating feeder and engaging it for the non-operating feeder. The process of engagement and disengagement of feeders is instantaneous, thereby assuring no interruption of the feed rate. As the feed hopper is not emptied completely prior to the change from one feeder to the other, the confining section will be filled with fibrous material except after complete clean-out or change-over of the system. In either of these cases, the confining section will have to be prefilled.

Alternatively, continuous operation may be obtained by utilizing two hoppers or feed reservoirs as shown in FIGS. 7 and 8. FIG. 7 depicts a V-type arrangement with two hoppers 106 and 108 having a common discharge and hinged gate 110 for sealing off the hopper being refilled with fibrous material. Each hopper has its own ram 112 and 114, with the design of the rams differing to provide the proper pressure distribution across the pronged conveyor 116. FIG. 8 depicts another arrangement with twin hoppers 118 and 120 in combination with a belt-type pronged conveyor 122. Each hopper has its own ram 124 and 126 and the rams are similar in design. Each hopper has a slide gate 128 and 130 for closing the hopper bottom during reloading. Gate 128 is shown in dotted lines to indicate the hopper is open. In the dual hopper arrangements the ram is raised into the upper portion of the hopper during reloading which takes place through a hinged door (not shown) in a side of each hopper. In the absence of a door, the ram could be completely withdrawn and reloading accomplished through the open top of the hopper.

FIG. 9 shows a preferred drum-type feeder apparatus for metering particularly cohesive fibrous materials such as nylon fluff. The illustrated feeder apparatus is mounted on a suitable frame (not shown) and differs from the apparatus of FIG. 1 in that a perforated, flexible belt 130 is driven by pulley 131 at a peripheral speed equal to that of the drum in a known manner. The overlying belt is clearly shown in the vertical section illustrated in FIG. 10. Means for driving pulley 131 are similar to those illustrated in FIG. 5. Alternate means for driving may consist of a second sprocket on the shaft of the drum which drives a sprocket associated with the pulley by means of a chain or belt. The prongs 134 are staggered for more effective entrainment. As shown in FIG. 11, the perforations 136 in perforated flexible belt also are staggered to coincide with prongs 134. The perforations 136 generally are elongated.

gated to facilitate entry and retraction of the prongs. Perforated belt 130 is supported by slide plate 142 just below the point at which pronged belt 132 disengages or retracts therefrom. Hinged entrapment segment 140 extends over a portion of the slide plate 142. Fibrous product is removed from perforated belt 130 by an adjustable, flat-bladed scraper 144.

In operation, perforated belt 130 engages pronged belt 132 prior to the point where it enters the open bottom of the hopper where the compressed fibrous material is entrained on the prongs. Means for cutting such as a reciprocating knife 146 is located by the hopper to prevent compaction or balling of the material therein before the pronged belt 132 enters confining segment 140. Pronged belt 132 disengages or retracts from perforated belt 130 in confining segment 140 and the fibrous material is removed from the perforated belt 130 by scraper 144.

The volumetric feeding apparatus described herein is capable of achieving volumetric metering accuracies on the order of about ± 1 to ± 5 percent by weight.

While the invention has been described with reference to certain embodiments, it is not intended that such embodiments shall be regarded as limitations upon the scope of the invention. It will be obvious to those skilled in the art that other modifications and variations of the invention can be made and various equivalents substituted therein without departing from the principles disclosed or going outside the scope of the specification.

What is claimed is:

1. Apparatus for the volumetric feeding of fibrous materials comprising at least one hopper for said fibrous material, said hopper having an open bottom; means for applying a compressive force to said fibrous material in said hopper; conveying means for receiving said fibrous material from said hopper, said conveying means including a plurality of prongs for entraining said fibrous material; means for driving said conveying means past said open hopper bottom whereby said fibrous material is forced by said compressive force onto said prongs; confining means for forming and holding a layer of said entrained material on said prongs after advancing past said open hopper bottom, said confining means being a plate pivoted at one end and having a surface corresponding to the shape of said conveying

means; and means for removing said entrained fibrous material from said prongs.

2. Apparatus in accordance with claim 1 wherein said means for applying said compressive force are adjustable and said plate is operatively linked to an automatic control means adapted to increase or decrease the pressure medium to said compressive means in response to changes in the position of said pivoted plate whereby the volumetric rate of flow of said fibrous material is substantially constant.

3. Apparatus in accordance with claim 1 wherein said means for driving is adjustable and said plate is operatively linked to an automatic control means adapted to increase or decrease the speed of said driving means in response to changes in position of said plate whereby the volumetric rate of flow of said fibrous material is substantially constant.

4. Apparatus in accordance with claim 1 wherein said conveying means comprise a rotatable drum with a flexible belt having spaced projecting prongs secured to said drum surface.

5. Apparatus in accordance with claim 1 wherein said conveying means comprise a flexible belt having spaced projecting prongs and a flexible, perforated belt overlying said pronged belt.

6. Apparatus in accordance with claim 1 wherein said conveying means comprises an endless belt having spaced prongs projecting from its outer surface throughout the entire length and width of said belt.

7. Apparatus in accordance with claim 1 wherein said discharge means is a scraper having longitudinal slots to allow said prongs to pass therethrough.

8. Apparatus in accordance with claim 1 wherein the speed of said means for driving is adjustable and said fibrous material is discharged onto a weigh belt having a continuously operative load cell which is operatively connected to control said speed to maintain a substantially constant weight of fibrous material on said weigh belt.

9. Apparatus in accordance with claim 1 wherein said means for applying a compressive force comprises a hydraulic or pneumatic cylinder capable of applying a variable force to material in said hopper whereby a gradually diminishing force can be applied to said material.

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